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Developing Capacity for Research and Advanced Scientific Training: Lessons from World Bank Experience

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DEVELOPING CAPACITY FOR RESEARCH AND ADVANCED SCIENTIFIC TRAINING LESSONS FROM WORLD BANK EXPERIENCE

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ABSTRACT

The importance of higher education and research for human capital accumulation and for economic growth is well established. World Bank lending for higher education and science and technology has risen significantly. This paper describes Bank lending strategies for higher education and science and technology development and draws four lessons from project experience. First, the Bank has been most successful where, through a series of project investments, it has developed a coherent sub-sectoral strategy for supporting quantitative expansion, quality improvement, strengthening national research and training capabilities and fostering their utilization by the private sector. Second, capacity building must comprehensively address the need to reform the financing and management of higher education and research systems. Changing the role of the state is usually fundamental to these reforms. Third, efforts to increase the efficiency of government and donor investments in higher education and research must combine strengthening accountability with increasing institutional autonomy. This will often involve changing traditions of subordination—liberating higher education and research institutions from civil service regulations, allowing them greater control over their budgets, encouraging openness, transparency and competition in resource allocation and, of course, protecting the integrity of academic and scientific work. Finally, countries with significant capacity for research and advanced scientific training will derive little benefit from their investments unless attention is also paid to fostering the use of such capacity by enterprises, producers, government and society as a whole.

Developing Capacity for Research and Advanced Scientific Training: Lessons From World Bank Experience

Introduction

The importance of higher education and research for human capital accumulation and for economic growth is well-established. World Bank lending for higher education and science and technology development has increased significantly. Between 1970 and 1991, lending for higher education amounted to US\$5.0 billion, of which 50% was lent between 1985 and 1991. The science and technology component of higher education lending amounted to US\$2.16 billion, of which 63% was invested between 1985 and 1991. Over the same period, lending for science and technology in industry totaled US\$1.0 billion, of which 81% was lent between 1985-1991. This growth reflects the global trend that development is increasingly knowledge-driven.

Nevertheless, higher education and research systems are in crisis in an increasing number of developing countries. Such countries account for less than 2% of global investments in science and technology, and for much less of the world's total research output. Many developing countries are trapped in a vicious circle in which a deteriorated higher education sector and the financial collapse of their scientific and technological infrastructure have virtually excluded them from the international exchange of knowledge.

The dramatic expansion of higher education systems in developing countries beginning in the 1960s transformed support for this sub-sector into an important domain of development assistance. However, assistance for higher education has been strongly criticized on the grounds that the needs and economic and social benefits of investing in other sub-sectors of educational systems are more compelling, particularly primary education (e.g. Great Britain 1970; World Bank 1974; Psacharopoulos and Woodhall 1985; World Bank 1986a; 1988).

Nevertheless, three circumstances ensure continuing donor support for higher education and research. First, secondary school participation rates in most developing countries, especially in Asia and Latin America, have grown appreciably since 1980, generating requests for assistance to accommodate the increasing social demand for higher education. Second, both national and donor educational investment strategies now connect such investments not only to the success of macro-economic policies to improve international economic competitiveness, but to expanding educational opportunities for women and educationally disadvantaged groups as well as to addressing many social objectives of development planning. Finally, investments in higher education and research have become more important to donors as a means of institutionalizing human resource investments in health, agriculture, transportation and other sectors. While higher education remains a high priority in development assistance, attention is drawn in this paper to the frequent lack of a comprehensive strategy for supporting advanced scientific training and research. The first section of the paper analyzes the evaluation of assistance strategies that now emphasize policy reform and selective support of research and training activities. The next sections examine recent trends in World Bank lending. The concluding section draw lessons from Bank experience in strengthening higher education and research systems.

Strategies for Assisting Development of Higher Education

The World Bank did not become involved in lending for higher education until 1963 at a time when many countries in Africa, Asia and the Caribbean were becoming independent and rapidly developing bureaucracies to manage public investments designed to stimulate economic growth. Educational expansion in the 1960s was the keystone of economic planning, social policies and of strategies for fostering political development. This was the Golden Age of foreign educational assistance and coincided with expansion of higher education systems in most of the donor countries.

Institution Building

Throughout most of the developing world in the 1960s, there was a critical shortage of administrative, scientific and technical manpower. The situation was particularly acute in Africa where higher education institutions had been established only recently and the senior ranks of the public services were staffed predominantly by expatriates. The newly independent African nations lacked personnel trained in many areas of high priority for their future development. For example, French Africa produced only four university graduates in agriculture in the period 1952-63 and British Africa about 150 (Yudelman 1975, 356). Assistance for foreign training and institutional development was sought to rectify the situation, often accompanied by the transfer of the institutional training models of the donor country as was the case at the University of Nigeria at Nsukka which, when it opened for instruction in 1960 with assistance from the United States Agency for International Development, was Africa's first Land Grant university.

Such bi-lateral assistance was intended to strengthen institution- to-institution linkages, "twinning relationships," between universities in developed and developing countries. This followed the earlier practice of developing new institutions in affiliation with metropolitan universities like the University of London and the Universite de Bordeaux. A large number of developed country universities were once involved in institution building overseas. In 1965, for instance, 72 American universities were assisting 74 universities in 31 developing countries under contract to the United States Agency for International Development (Coleman and Court forthcoming, 17). The new institutions received long term holistic support; i.e. funds to construct teaching, research and residential facilities, and funds for staff development, expatriate staff, curriculum development, to train administrative and support staff, and even for a significant proportion of their operating costs.

Institution building provided opportunities to project the educational, political and cultural influence of the donor countries. In the social science literature of the 1960s, higher education was presented as being crucial to creating a modern polity through political socialization, political recruitment and political integration. Universities were viewed as especially important for elite recruitment and national integration for "the bureaucracy remains overwhelmingly dominant" (Coleman 1965, 28). There was a high degree of congruence between the policies of donors and the needs articulated by recipients. Governments in developing countries wanted support for institutional development and foreign training. Most donor agencies competed to supply the resources they required. Assistance could be justified by prevailing wisdom about the educational causes of economic growth (Denison 1962), extrapolating findings from developed to developing countries. The most influential studies demonstrated the productivity raising effects of investments in higher education (e.g. Schultz 1960; 1963) and showed that the magnitude of effects increased with educational level (e.g. Renshaw 1960).

In all, more than two hundred universities in Latin American, African and Asian countries received assistance between 1960 and 1975 from bi-lateral assistance agencies representing Australia, Belgium, Britain, Canada, China, Denmark, France, Japan, the Netherlands, Norway, the Soviet Union, Sweden, the United States and West Germany, four international philanthropic foundations, multilateral donors such as the World Bank and from the technical agencies affiliated to United Nations organizations (Coleman and Court forthcoming, 16).

The World Bank's first project with a higher education component (1963) supported secondary teacher training in Tunisia. A loan was sought to finance construction of middle and secondary schools as well as new facilities for an Ecole Normale de Professeurs Adjoints. The recently established Université de Tunis would be an indirect beneficiary of the project since "once the number of secondary school graduates had expanded sufficiently, most university subjects would be taught" (World Bank 1962, 4). Like many of the World Bank's early higher education projects, the rationale for its involvement focused on the country's manpower requirements: "The shortage of skilled manpower, aggravated by the withdrawal of the foreign population, is a major impediment to economic growth" (World Bank 1962, i). Manpower planning connected development theories emphasizing the importance of human capital to specific educational investments (Harbison and Myers 1964).

Table 1
Number and Kinds of Higher Education Investments,
1963-1991

Institution	63-70		71-75		76-80		81-85		86-91		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Universities	10	29	25	26	26	26	23	26	38	34	122	28
S&T Research Institutes	0	0	1	1	0	0	3	3	13	12	17	4
Polytechnics	3	9	9	9	6	6	9	10	10	9	37	9
Technical Institutes	7	20	30	31	34	34	19	22	17	15	107	25
Teacher Training Institutions	15	43	33	34	34	34	34	39	33	30	149	34
Total	35	100	98	100	100	100	88	100	111	100	432	

Pakistan was selected for the World Bank's first university project (1964) which was also the first education project whose primary purpose was to support higher education. The project addressed two key sectors where manpower planners had identified shortages that were said to be critical; agricultural professionals and industrial technicians. On the advice of the country's Food and Agriculture

Commission and with assistance from the United States Agency for International Development, Pakistan had recently established two agricultural universities in the western and eastern wings of the now divided country. The two universities were twinned with Washington State University and Texas Agricultural and Mechanical College (now Texas A & M University) while the technical teacher training institutions supported were being assisted by Oklahoma State University with funds from the Ford Foundation. World Bank funding was made available for construction of facilities, purchase of equipment and for expatriate personnel.

The collaboration between the World Bank and the United States Agency for International Development in the development of agricultural universities was typical of several projects of this period, ten altogether, including projects to support establishment of the University of the Philippines-Los Banos and Kaesertart University (Thailand). According to a World Bank evaluation of assistance for agricultural higher education, "assistance from the two sources was reinforcing, with the Bank providing hardware items and USAID the software items—usually staff and curriculum development" (World Bank 1992, 52).

Between 1963 and 1975, the World Bank supported 34 projects or project components directed to universities. But most (102) higher education projects or project components supported teacher training, technical or polytechnic institutions. Still, university projects accounted for a majority (54%) of World Bank lending for higher education.

In the early 1970s, the priorities of donors and recipients gradually began to diverge while the economic and political justifications for high levels of donor and government investments in higher education, particularly in university development, were being questioned. There were frequent conflicts between donors and many developing countries—as well as among donors—over the pace and direction of expansion of higher education.

The University of East Africa was one of the high points of the institution building era. Established in 1963 by amalgamating three university colleges, it supplied teachers, agriculturalists, doctors and other professionals to the entire region. The effort was supported by a consortium of bi-lateral donors led by the Americans and the British who had co-operated in the development of higher education in East Africa for several decades. However, the University of East Africa became a source of serious political discord as the three national constituent colleges attempted to replicate programs with encouragement from some new donors. Donor competition and increasing antagonism between donors and governments eventually led to the dissolution of the University of East Africa in 1970 (Southall 1974).

Over-Investing in Higher Education?

The International Council for Educational Development carried out a comprehensive review of foreign assistance for higher education in Latin American, African and Asian countries in 1974-75. It was intended to answer a question posed by the World Bank's representative but shared by the eleven other donors supporting this initiative: "Is the contribution to development by higher education less than it might be? (Thompson and Fogel 1976, 3).

The Council's final report, produced by teams of developed and developing country academics and university administrators, identified several foreign assistance success stories (Thompson, Fogel and Danner 1977) and concluded that "many institutions are doing innovative things, that something is being

done about development education and that the ivory tower stereotype does not fit the institutions studied" (Thompson and Fogel 1976, 5). The report did little to alleviate donor skepticism about investments in higher education, however.

Some educational economists were beginning to conclude that developing countries were "over-investing" in higher education and that resources should be re-directed to primary education. This theme was amplified in World Bank educational research and policy statements throughout the 1970s and early 1980s. The World Bank's 1971 Education Sector Policy Paper proposed more emphasis on primary and even non-formal education. The 1974 Education Working Paper criticized the disproportionate allocation of educational resources to secondary and higher education that served the modern sector, resulting in underfinancing of basic education which was the more efficient and more equitable investment. Donor and national investment strategies should place a high priority on achieving universal basic education while expenditure for secondary and higher education should be strictly related to critical manpower needs.

The 1980 Education Sector Policy paper, the most recent statement of World Bank policy for investment in education, focused on equity issues and on expanding access to basic education within the framework of measures to promote cost effectiveness and external efficiency. It raised concerns about reliance on manpower forecasting and the enthusiasm of many developing countries for vocational training, though it favored investments in polytechnics and other forms of technical training as an attractive alternative to high cost university studies.

It is impossible to ascertain exactly what influence these studies had on the assistance programs of the World Bank and other donors. There is some evidence that bi-lateral support for higher education was declining before "over-investment" in higher education was accepted as an established development fact. For example, Coleman notes that "by 1970 the number of universities in (US)AID programs had declined to 66, by 1974 to 18 and by 1978 to only 10" (Coleman and Court 1993, 17). Support for higher education from the Inter-American Development Bank dropped from 72% of education lending between 1965 and 1970 to 19% by 1980. In 1975, the British government issued a White Paper proposing a shift "from helping universities to helping with vocational training and other aspects of education which are closer to the grass roots" (Coleman and Court 1993, 18). In the same year, the Rockefeller Foundation began phasing out support for university development in African, Asian and Latin American countries, an activity in which it had been a leader for almost half a century.

It is surprising, in retrospect, how quickly some donors and many governments in developing countries discarded their preoccupation with maintaining what Ashby (1966) aptly described as the metropolitan "gold standard" of higher education. The dependency theory/cultural reproduction critique of development assistance which disparaged support for elitist higher education as neo-colonial (Newbry 1969; Mende 1973; Carnoy 1974) undoubtedly caused some embarrassment. It equated adherence to metropolitan practices with "servitude of the mind" (Altbach 1977). The international philanthropic foundations could have been expected to be less sensitive to such criticisms than the bilateral or multilateral donors, especially in light of their substantial investments in centers of excellence. However, the mounting disillusionment over both the developmental record and the promise of higher education in the Third World was exacerbated by a sort of synergistic negativism from the wide spread disenchantment in the industrial Northern countries generated by their own student rebellions and universities crises of the late 1960s. Throughout the world, universities confronted rapidly eroding esteem and support. The halo and veneration so lavishly and uncritically bestowed upon them everywhere during the previous two

decades suddenly evaporated; almost overnight they were perceived no longer as the solution to the problem of development, but as a central part of the problem itself (Coleman and Court 1992, 11). In brief, "the weakness of the universities was more that, like the modern sector itself, they were located in towns, were costly and served a small number of people" (King 1991, 244).

The number of World Bank projects involving universities declined from 27 in the period 1976-1980 to 22 between 1981 and 1985 while the total number of higher education projects fell from 98 to 87. A typical World Bank education project of the period was a 1976 loan to Liberia whose principal objectives were to increase the coverage of primary schooling and adult literacy programs in rural areas, expand vocational training and assess the feasibility of radio for formal and non-formal education. Some project funding went to support teacher training and development of research capacity at the national university to monitor the effectiveness of project activities.

Nevertheless, the volume of lending for higher education more than doubled between 1976-80 and 1981-85 (from \$603.9 M to \$1,493.5 M), growing from 28% to 43 % of education lending—this despite the Bank's sector policies and investment analyses. At the same time the World Bank was becoming increasingly important to developing countries as a source of educational assistance. From 1970 to 1975, the World Bank's share of total educational assistance increased from 5% to 10% (Phillips 1977) at a time when educational assistance provided by major bilateral donors like the United States Agency for International Development was decreasing in real terms (Method 1981, v).

Human Resource Development and Capacity Building

Educational assistance is now provided under programs for human resource development and capacity building. These terms have supplanted investment in human capital in donor usage though they have a common origin in the influential work of Harbison and Myers (1964, 2). Early strategies for human resource development focused on investments in schooling and implications for employment. Today, human resource development comprises the social sectors of development assistance—education, population, health and nutrition—in recognition of their inter-relationship and joint contribution to economic growth (Hicks and Boroumand 1980; Wheeler 1980).

This more inclusive formulation of the scope of human resource development has made it easier to justify investments in secondary and higher education. So long as attention focused on the marginal returns to different educational investments measured in terms of increases in lifetime earnings, increased investment in higher education was difficult to justify the basis of efficiency or equity. In part, that was an artifact of the earnings data used to calculate rates of return to investments in primary, secondary and higher education. The modern sector for which earnings data are most readily available, is dominated by government employment and accounts for a small proportion of the labor market in many developing countries. It absorbs a much higher proportion of graduates of secondary and higher education institutions than primary school leavers. Since public service wage and salary structures rigidly link earnings to schooling producing large earnings differentials that are not recouped through individual taxation, social returns to educationally investments usually decrease with level of schooling while private returns increase (Psacharopolous 1973; Psacharopolous and Woodhall 1985, 56 & 57). The findings favored investments in primary schooling.

Studies of health, nutritional and fertility behavior began to show a strong relationship between schooling and these important outcomes of human resource investments (e.g. Cochrane, O'Hara and

Leslie 1980; Cochrane 1979). While that did not justify increasing donor investment beyond primary schooling, it did support investments in extension of health, education and social services particularly for rural and special populations such as women. It also prompted donor recognition that weak institutional infrastructures, poor management capabilities and lack of well-trained professional counterparts were serious impediments to assistance efforts (USAID 1984). Human resource development divisions were created within many donor agencies in the 1980s, often with modest financial resources, ambitious but ambiguous responsibilities and ill-defined relationships to traditional sector operations (Simpson and Sissons 1989).

More significant for institutions of higher education in developing countries was increasing support for training programs and research on themes of concern to the donor community. Among the first were inter-disciplinary social science programs in development studies which have had a precarious existence since their establishment at the urging of the international philanthropic foundations (Court 1979). Donor support of activities relating to women in development (WID), women and development (WAD) and gender and development (GAD) has had more impact. The 1973 Percy amendment to the Foreign Assistance act required that the United States Agency for International Development give particular attention to women (Morgan 1984). This initiative was soon copied by many donors, influencing assistance strategies (Staud 1985) and eventually requiring "institutionalization" in the form of support for training and research on gender issues in developing country universities (Rathgeber 1990). Other programmatic initiatives followed in bewildering succession: environmental health, small farming systems, agro-forestry, and so on. Each became a high research and training priority for human resource development and resulted in a proliferation of university centers and programs often established to capture external funding. In funding training programs, donors had to work with developing country governments and universities, which could often be difficult.

Funding university researchers involved fewer obstacles and offered important opportunities to influence development planning. New donor agencies were established by some of the smaller OECD countries with mandates similar to the American international philanthropic foundations, and more resources to spend on developing country research. The International Development Research Center, for instance, was founded by Canada in 1970 to support applied research in the agricultural, health and sciences.

In the early 1980s, it was providing support for macroeconomics and technology policy studies at the University of Nairobi. The Swedish Agency for Research Co-operation with Developing Countries, founded in 1975, and the Swedish International Development Agency supported the University's Institute for Development Studies. The Ford Foundation funded social science research and training on women and development. Grants from the International Development Research Center alone exceeded the total budget of the Kenyan National Council for Science and Technology, the principal source of local funding for university research (Republic of Kenya 1983, Table VII). The involvement of many donors created powerful assistance constituencies within the University of Nairobi which was a source of academic conflicts (Rathgeber 1982). The separate, un-coordinated donor initiatives also increased the complexity of managing University programs that often incorporated incompatible features of different national systems of higher education such as the adoption of a credit system for courses with final degree examinations.

Donors became increasingly involved in determining what training institutions should provide, the staffing needs of institutions, and the priorities for research particularly in Sub-Saharan African

countries. The deepening crisis of university systems in African and some Asian countries throughout the 1980s led to a more proactive donor role in higher education and greater willingness by governments to engage in policy dialogue (World Bank 1986a; 1988).

**Box 1: Sector Adjustment Lending and Higher Education
Policy Reform in Senegal**

The Senegal Primary Education Development Project (1986) was designed to respond to the rapid expansion in primary education in the three regions of the country with the lowest enrollment rates. The project supported measures aimed at lower unit costs by improving the efficiency of resource use. Expansion would be without additional public resources, by restructuring intra-sectoral budget allocations. Resources from higher education would be reallocated to primary education by imposing growth ceilings on the higher education budget. Other measures included: a) the reduction of fellowship budget; b) the reduction of indirect subsidies to University of Dakar for student services; and c) the introduction of a cost recovery program.

Once the credit was in place, very little success was achieved in reducing expenditures on higher education. The situation moved in the opposite direction as required by the loan agreement. The higher education budget increased as a percentage of education spending, student subsidies increased dramatically, as did the amount and size of student scholarships. Fellowships increased 50% in real terms between 1986 and 1989. With assistance from bilateral donors, a new university was opened.

The attempt to reallocate funds for higher education to other sub-sectors pitted powerful elites - students, their parents and university staff - against the poor and politically voiceless clientele of the primary schools. In the end, the President of the Republic found himself negotiating with the student leaders and the Minister of Education was dismissed.

Source: World Bank (1986b). Senegal: Primary Education Project. (Washington, D.C.: World Bank).

Hincliffe (1985) set out the terms of reference for this dialogue in an analysis of African higher education: social demand for higher education was increasing at a time when the labor market for graduates was weakening; unit costs of higher education were too high by comparison to costs elsewhere; the internal efficiency of institutions was too low; and savings in expenditures for higher education should be made through increased student contributions. These findings were elaborated in the World Bank's 1988 policy paper on African education and became the basis of its policy dialogue with African governments. Governments were enjoined to limit or moderate enrollment increases by reducing or freezing student intake, to contain costs by lowering expenditures for academic and non-academic staff and student support and by rationalizing programs of study, and, finally, to recover costs through charging tuition, raising fees and initiating student loan schemes.

Donors increasingly moved "upstream" into influencing policies affecting the higher education sub-sector and "downstream" into program and research funding affecting training and the activities of staff. The various roles which donors found for themselves—whether it was supporting womens' studies, appropriate technology, family planning programs or improving the internal efficiency of higher education—reflected the low cost opportunities that expansion of university systems and the increasing inability of many countries to support them presented.

Recent Trends in World Bank Lending for Higher Education and Research

The World Bank has accumulated a great deal of lending experience in supporting universities, institutes for research and advanced scientific training, polytechnics, technical and teacher training institutions. Since 1963, it has had projects supporting three or more types of higher education institutions in six Latin American and Caribbean, eleven Middle Eastern and European, four South Asian and five East Asian countries, including many countries where it has supported all types of higher education institutions (Algeria, Brazil, China, Indonesia, the Philippines and Portugal). In 16 of 37 of the African countries assisted by the World Bank (37), projects have involved three or more types of institutions. However, a typical project with a higher education project component involves only one type of institution. Consequently, the benefits of World Bank experience in the higher education sub-sector in particular countries are cumulative rather than concentrated at any point in time.

Table 2

Number of Higher Education Project Investments by Region,
1963-1991

Region	63-70		71-75		76-80		81-85		86-91		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Africa	15	43%	30	31%	38	38%	25	28%	32	29%	140	32%
E. Asia	6	17%	18	18%	15	15%	20	23%	37	33%	96	22%
S. Asia	5	14%	7	7%	8	8%	11	13%	9	8%	40	9%
EMENA *	2	6%	30	31%	29	29%	23	26%	23	21%	107	25%
LAC **	7	20%	13	13%	10	10%	9	10%	10	9%	49	11%
Total	35		98		100		88		111		432	

* Eastern, Southern Europe and Middle East.

** Latin America and Caribbean.

World Bank Higher Education Investments, 1986-91

In the period 1986-91 (Annex Tables 1-3), World Bank education lending nearly doubled from 5% to almost 10% of lending to all sectors, evidence of the high priority that is now being given to human resource investments. The volume of lending for higher education increased from \$1,472.1 M to \$2,376. and the number of higher education project components from 87 to 105. The proportion of education lending for higher education fell, however, from 43% between 1981-85 to 35%. Nearly all of this relative decline can be attributed to rising support for primary education (Lockheed and Verspoor 1991, 212) as well as to the slow down in the growth of lending to China and Indonesia, the World Bank's largest borrowers for higher education.

East Asian countries account for 34% of recent higher education lending (1986-91), down from 71% in the early 1980s. Lending to South Asian and European and Middle Eastern countries has grown. South Asia's share increased from 4% to 20% of lending from 1981-85 to 1986-91. Higher education lending to African, Latin American and Caribbean countries has diminished relatively. For instance, African countries accounted for almost half (43%) of all higher education components in the 1960s. Africa's share of higher education has declined to 11% since 1986. Latin American and Caribbean countries received only 7% of higher education lending, and just 6% for the period 1963 to 1991.

If World Bank lending for higher education was distributed on the basis of the proportion of gross higher education enrollments represented by different regions—which, of course, it is not—the regional allocations would vary somewhat. In 1988, the latest year for which such information is available (Unesco 1988), East and South Asia accounted for about 60% of the developing world's higher education enrollment. These regions received 68% of World Bank higher education lending for 1986-91. Africa which has only 4% of the world's higher education enrollment obtained nearly four times as much funding.

Among regions, Latin America and the Caribbean have the lowest share of higher education lending relative to higher education enrollments (26%). In part, the explanation may have to do with the fact that the Inter-American Development Bank has given high priority to lending for higher education and advanced scientific training and research. For example, from 1962 to 1988, 60% of the Inter-American Development Bank's education loans were allocated for higher education and science and technology. This amounted to \$622.7 M, nearly twice total World Bank lending to the region.

The university share of World Bank higher education lending has continued to decline (to 37% since 1986) but if support to research institutions participating in advanced scientific training are included, their combined proportion has increased to 63%. East Asian countries have the highest number of project components focusing on universities and national scientific institutions reflecting economic growth strategies in most countries in the region that have required large national and international investment in universities and national research systems.

Investing in Advanced Scientific Training and Research: Brazil and Korea

Brazil is a scientifically advanced, developing country with a well elaborated higher education system and a large network of public scientific institutions. Like India and Argentina, Brazil is a major producer of science and technology and scientists and technologists. But it has not derived full benefit from its substantial research and training capacities for several reasons. The country's work force is still poorly educated and largely unskilled. The country's research and development capabilities are mainly concentrated in the public sector (Schwartzman 1991). There is a very low level of private investment in research and development and because of large, protected, oligopolistic internal markets, few incentives for technological innovation by state owned enterprises or by private firms (Dahlman 1984; Schwartzman 1991). Korea, though not one of the developing world's major producers of science and technology, has a well educated, highly skilled work force and a sophisticated, internationally competitive, research intensive manufacturing sector. This is the result of government policies that have emphasized public and private investments in all levels of education, expansion of key export industries, and utilization of the products of the country's public sector research and training institutions by private firms (Westphal 1978, Westphal, Rhee and Pursell 1984). The two countries present an interesting contrast in scientific,

educational and industrial development as well as in Bank lending strategies to strengthen higher education and research.

Supporting Scientific Training and Research in Brazil

In 1983, Brazil obtained a loan from the World Bank for expanding agricultural and industrial training, following on the First Education Project loan (1971) which supported establishment of eight agricultural and two industrial technical schools. Despite evidence of an over-supply of agricultural technicians and university trained agriculturalists, a shortage of "middle-level" personnel was perceived, particularly in the most underdeveloped northeastern regions (World Bank 1983, 5). In the manufacturing sector as well, while the labor market could not absorb university graduates, a shortage of technicians was said to exist. This could not be remedied by "downward substitution of engineers (because that) would normally lead to lower levels of job performance...and to un-necessarily high labor costs" (World Bank 1983, 6). The project financed short-term expansion of the output of secondary agricultural and technical institutions in conjunction with development of long-term government manpower training policies for these sub-sectors.

For many years, the World Bank provided little assistance to higher education apart from what was necessary to support Brazil's agricultural research system and expand research on non-fossil fuels and the ecology of the Amazon basin. No rationale had been developed for greater involvement in the higher education system. Indeed, from a sectoral perspective, there was little justification for major investment.

The Science and Technology Project approved two years later (1985 for \$72 M) reflected a radical change in the World Bank's approach to the higher education sub-sector. Better exploitation of the country's agricultural, mineral and other natural resources is presented in this project as requiring increased investment in the country's infrastructure for scientific and technological training and research strained by the rapid growth of enrollments during Brazil's economic miracle from 1964 to 1979 and, subsequently, by economic crisis. A rationale for investment is developed focusing on the implications of investments in research and training for economic growth and the country's poor performance on science indicators relative to OECD and East Asian countries:

Brazilian science and technology boasts numerous examples of the impact of indigenous research on economic growth, even under the sub-optimal sectoral conditions currently prevailing....In an environment of severe scarcity of public resources, Brazilian authorities (and the country's external financiers) may fail to give sufficient attention to those research and human resources development activities of longer term and less certain results upon which Brazilian technological capacity—and international competitiveness—in the next century ultimately depends (World Bank 1985, 55 & 57).

Sector work identified the principal weaknesses of Brazil higher educational and national research systems as: a) dispersion of scarce resources "across too many discrete (research and training) activities" with the result that projects and programs are inadequately funded; b) "over production of dubious quality personnel (in some fields while) especially in the sciences, the numbers of highly training professionals needed...for intensifying research and development in priority areas, or for immediate employment in the productive sectors have not materialized;" c) "mismatch between availability and orientation of scientific and technological expertise, and the unexploited natural resource base and acute development challenges

in the northeast, center-west and north;" d) poor scientific support services and access to scientific and technological information; and e) ineffective mechanisms for setting scientific and educational priorities and funding projects and programs (World Bank 1985a, 6 & 7).

A human resource sub-program to expand postgraduate and diploma training in higher education institutions located in natural resource rich but scientifically and educationally less developed regions was funded together with a large targeted research grants program mainly in applied fields serving agriculture, industry and energy administered by the Agency for Financing Studies and Projects. Procedures for peer review of research proposals carried out under the auspices of the Federal Secretariat for Science and Technology were to be strengthened. Investments were also made in informatics, weather forecasting services, improving industrial standards and quality control assessments and in developing local capacity to produce reagents and repair and maintain scientific equipment. As well, funding was made available for science curriculum development, improving science teacher training and for science popularization.

A second scientific research and training project was approved in 1990 "to consolidate the still fragile institutional reforms made in the first project, such as open competition, peer review, and decentralized planning, as well as rationalization of the importation process and strengthening of industrial norms" (World Bank 1990a, 12). The project continues the focus on the public sector research system and "activities which the private sector will not finance." Additional funding is provided to the applied scientific fields supported by the earlier project and two more are added; materials science and environmental studies. Almost half (46%) of project funding (\$150 M) is to be expended for purchase of scientific equipment.

Box 2: Support for Peer Review and Competitive Research Funding in Brazil

The awarding of research funding on a competitive basis is a major departure from previous practices and is a key element of the World Bank strategy to strengthen Brazil's scientific community. However, implementation has been difficult despite the strong support for the principle of competitive funding from many researchers and now several years of experience. In the current Scientific Research and Development Project, there are still problems in scheduling disbursements so that there are two to three rounds of research awards per program per year. A high proportion of funds have been committed too early in the project cycle. A related difficulty is that the national funding agency has not retained 20% of the funds to be allocated in each round for support of new projects, completion of ongoing projects and reconsideration of previous requests. Research committees have compounded this situation by determining a priori not only the volume of resources to be expended in each round, but also the number of projects to be approved. These practices have substantially compromised program flexibility.

In addition, the guidelines developed for many of the programs have been confusing to applicants, results have not been announced in a timely manner and disbursements to successful researchers have been delayed, especially grants made for purchase of imported laboratory equipment. Moreover, in at least one of the research sub-programs, the impartiality of the peer review process has been called into question. Many members of this research committee (40%) had projects funded by the program. (While that casts suspicion on the review process, it may simply indicate that at least some committee members are active researchers.) In another program, a majority of project proposals were deemed to fall outside program guidelines and, thus, were not sent out for expert peer review.

Source: Kuperman, A. (1991), "World Bank Supervision Report for Brazil Science and Research and Training Project," Washington, D.C.: World Bank, processed.

Much of the rationale presented for these project investments rests on the assumption that Brazil is not producing enough high quality science and well trained scientists and engineers. The problem is insufficient research and training capacities rather than insufficient utilization of the country's public higher educational and research assets by productive sectors. Yet the appraisal report for the most recent project draws attention to many areas of concern. The public sector, it notes, may finance as much as 90% of total scientific and technology investment (World Bank 1990a, 34), a much higher proportion than in many OECD and East Asian countries. While state funding has declined from the early 1980s as a result of continuing austerity, overall Federal Government spending on research and development has remained stable, reflecting "not only the political power of the Science and Technology community, but also a favorable attitude of the Brazilian Congress toward funding of Science and Technology activities" (World Bank 1990a, 35). The prominent involvement of the Federal Government is not a peculiarity of Brazil: "...What is worth noticing is that while Brazil (has) remained extremely dependent on public funding for S&T expenditures, other countries have been able to evolve toward a growing share of privately financed Research and Development as their industries matured. The most striking example in this category is South Korea (World Bank 1990a, 38).

As Brazil's economic crisis deepens, there is growing under-utilization of these assets as evidenced by declining private investments in research and development, and further concentration of research activity in public scientific institutions (Wolff 1991). Meanwhile, Brazil's production of mainstream scientific papers has increased from 3,412 scientific papers in 1985 to 4,129 in 1990 (ISI 1985, 1990). Brazil is a rare example of a country in economic turmoil whose scientific community is almost entirely dependent on government research funding, that has sustained its mainstream scientific

output (Eisemon and Davis 1992). The production of postgraduates in scientific and technological fields has also continued to increase. In 1988, about 28,000 students were enrolled in postgraduate programs in Brazilian universities which graduated 4,300 students that year, three fourths in applied scientific fields (Unesco/CRESALC 1991, 31 & 48). More recent estimates put the number of postgraduate students as high as 50,000 (Wolff 1991, 11). Ten per cent of Federal Government investment in advanced scientific training and 40% of competitive research funding, most of which is captured by universities, is presently derived from World Bank loans (Wolff 1991, 6).

Macroeconomic reforms introduced by the Federal Government in the early 1990s have profound implications for whether the country will ultimately benefit from investments in expanding its higher education and science and technology systems. Protected internal markets are being opened and firms encouraged to compete, with tariffs being reduced substantially. State owned enterprises which account for a substantial share of national research and development investment will soon be privatized. Such measures might stimulate private research and development and greater utilization of the research and training capabilities in public sector scientific and higher education institutions. But they might also extinguish much of this capacity as Brazil does not possess obvious comparative advantages as a source of applied scientific and technological research in many of the fields in which government has invested heavily such as electronics and computer science.

Much will depend on the structures the country develops to facilitate research utilization and stimulate technological innovation as well as on investment in increasing the educational and skill level of the labor force. Brazil's science and technology system is conspicuously underdeveloped in terms of mechanisms to transfer applied science from the public to the private sectors (Schwartzman 1991). Strategies for rectifying this situation are only now being studied under the auspices of the Second Science Research and Training Project (World Bank 1990a, 15). Poorly designed revisions of the tax regime in 1988 to increase private investments in research and development have not significantly changed firm behavior and will need to be recast, and different incentives devised especially for small and medium sized firms. More important, increased investment in basic education will be required to fully exploit the country's scientific and industrial potential.

Investing in Science and Technology in Korea

Korea illustrates a successful integrated sub-sectoral, sectoral and inter-sectoral approach to developing national scientific and industrial capacities. Korea up to the 1960s, like Brazil today, had a relatively large, mostly private, mainly poor quality higher education system oriented to undergraduate instruction (Lee 1989). The first American model postgraduate programs in science and engineering were not established until 1961 (Lee 1989, 40). Compared to Brazil and also to many Asian and African countries that experienced colonialism and whose scientific institutions were linked to imperial scientific systems (Eisemon, Davis and Rathgeber 1985), Korea lacked a significant public infrastructure producing applied research and providing various scientific services. However, there was no tradition of a dominant role for the state in advanced scientific training and research to be perpetuated. Instead, there was much scope for carefully planned, high impact public investments in a predominantly private higher education system.

Korea was fortunate in another respect as well. At a time when prevailing development ideologies gave importance to government mobilization of resources for technological innovation fostered by restricted access to foreign technology, Korea had to import technology as it was unable to generate

much of its own (Westphal, Rhee and Pursell 1983). It relied on private investment and foreign training for this purpose while the country developed long-term scientific, industrial and educational strategies intended to build technological capacities.

In 1949, Korea re-organized its educational system, made primary education a government responsibility and established increasing coverage of the primary school age cohort as a national priority. In the mid-1960s, the Minister of Education approached the World Bank for a primary education project:

However, the Bank's...reaction was negative: the Minister was advised that the project in which he was interested at the time—primary school construction to accommodate the growth in population of primary school age—did not qualify under Bank criteria since neither normal population increase nor primary school construction was eligible for consideration (World Bank 1977, 1).

Secondary technical and vocational education were considered more appropriate investments for the World Bank at the time. Thus, the First Education Project (1969), and the next three (1973, 1975 and 1977), expanded vocational and technical education. In the first project, the government requested some assistance for development of university level training in engineering, marine biology and basic science to compliment investments at the pre-university level. The World Bank did not think that this was advisable (World Bank 1977, 1). The Second Education Project (1975) had a small technical teacher education training component at the university level, though the World Bank expressed reservations about this as well (World Bank, 1983, v).

By the Third Education Project (1975) the World Bank was ready to become somewhat more involved in supporting higher education; specifically, by providing funding for three agricultural colleges, a fisheries college and a merchant marine college. The Fourth Education Project (1977) continued support to secondary and post-secondary vocational and technical institutions. It was implemented in the context of universal primary education, achieved in 1975, and rising secondary school participation which reached more than 80% by the early 1980s.

While the World Bank was investing in the periphery of Korea's rapidly expanding university system, the government was moving to control growth of the tertiary level. In the mid-1960s, the government tried to introduce quotas on the intake into private institutions which as early as 1945 accounted for the majority of university enrollments (Lee 1989, 37). In 1982, it enlarged the functions of the former Korean Association of Universities and Colleges making the new Korean Council for University Education an accrediting body for all institutions of higher learning. Substantial government funding was made available for foreign training and expansion of postgraduate programs to facilitate staff development in both public and private institutions. Between 1967 and 1983, the proportion of university staff holding a doctorate increased from 10% to 40%. The majority (61%) had degrees from Korean institutions (Lee 1989, 39).

Throughout the 1970s, Korean firms increased purchases of technology from abroad, mostly from Japan, though even firms in export industries were relying mainly on endogenously developed "know how" (Westphal, Ree and Pursell 1983, 282 & 284). Local "know how" refers to the ability to assimilate, adapt and innovate upon new technologies. By the early 1980s, it could be claimed that "Korea's proficiency in plant operation far surpasses that in product and plant design" (Westphal, Ree and Pursell 1983, 291). The country's "know how" capability enhanced through investments in primary,

secondary and vocational education, and creation of a mass system of higher education, as well as its relative openness to foreign technology, was far in advance of its "know why" capability to invent production technologies derived from basic science (Fransman 1984, 10).

The government was already taking important steps to rectify this situation. The Korea Institute for Science and Technology was founded in 1966 and the Korea Advanced Institute of Science in 1971 to promote basic research and advanced scientific training outside the public and private universities, to more efficiently utilize scarce research resources in institutions where a critical mass of expertise could be developed, and research and training efforts focused on industrial needs (World Bank 1978, 4). These institutions were later merged to form the prestigious Korean Advanced Institute of Science and Technology in 1981.

Increased funding was made available to support expansion of postgraduate training at elite public and private universities as well as at government institutions carrying out advanced scientific training and research resulting in a more than tenfold growth in the output of Master's and doctoral students between 1965 and 1986 (KEDI 1986, 194-195). Government funding for university based research also increased, and between 1980 and 1985, the production of mainstream research in basic and applied scientific fields rose dramatically (Eisemon and Davis 1989, 335). Although government economic plans established specific industrial priorities, research production and graduate training was concentrated in high quality institutions rather than in particular fields of commercial importance (Eisemon and Davis 1989, 53; Lee 1989, 42).

By the early 1980s, private research and development expenditures already exceeded those directed by government to universities and public scientific institutions (Kim 1986). This reflected private sector response to a plethora of government policies to stimulate "industrial dynamism (Westphal 1978; 1981), "chiefly through incentives to firms involved in technology intensive export markets, coupled with generous tax exemptions for research and development investments (Lee 1989, 51 & 52). In brief, Korea was creating a private sector market for the products of its higher education and science and technology systems while it was expanding its capacity for advanced scientific training and research through government investment.

A \$100 M World Bank loan approved in 1980 supported expansion of training in management, engineering and certain technical fields, the bulk of the funding being allocated to expanding engineering and the majority of that to private institutions most in need of qualitative improvement. An important feature of this project was the development of an accrediting body for engineering institutions. Student teacher ratios were to be significantly reduced as government increased salaries and funding for research and staff development (World Bank 1980a, 22). In contrast to earlier projects and most other higher education projects of this period, the Higher Technical Education project covered "the whole sub-sector, public and private" (World Bank 1980a, 26).

Four more projects were approved between 1989 and 1991, involving total loans for higher education and scientific research of \$153 M. One project will fund a competitive research and equipment grants program for universities in recognition of the fact that about 60% of scientists and engineers engaged in research and development with postgraduate degrees are employed in universities (World Bank 1990b). The others are designed to strengthen links between public sector science and technology producing institutions and industrial users through support for the rapidly proliferating linking mechanisms that the government has established for this purpose. The list of beneficiaries includes the

Industrial Technology Center, the Korea Electro-technology Research Institute, the Genetic Engineering Center, the Korea Standards Research Institute, the Korea Institute of Energy and Resources, the Korea Basic Science Centers, the National Institute of Industrial Research as well as the country's flagship research and training institutions, the Korean Institute of Technology and the Korean Advanced Institute of Science and Technology. Guiding these efforts is the government's four-pronged strategy of: a) concentrating talent in high priority basic and applied scientific fields; b) encouraging inter-disciplinary research and training activities; c) facilitating collaboration between the university research community and the productive sectors; and d) focusing research training on topics with industrial applications.

Box 3: The Korean Basic Science and Engineering Research Centers Program

Funded through the Korean Science and Engineering Foundation, the program makes long term institutional development grants to universities on a competitive basis. Importance is given to supporting training at the postgraduate and at the undergraduate level "in areas where industrial personnel are needed." (Korea Science and Engineering Foundation 1991). In the 1989 and 1990 competitions, the Korean Science and Engineering Foundation made 30 grants to universities, 14 for Basic Science Research Centers and 16 for Engineering Science Research Centers to support activities in such fields as molecular plant biology, artificial intelligence, bio-process engineering, satellite technology research, and dialectic and advanced matter physics. The centers encourage exchange of personnel between universities, government research institutions and industries and their research projects are jointly developed by representatives of these sectors. They collect membership fees to support some of their operating costs from government institutions and private firms which makes them partners and ensures that the intended beneficiaries of the program take an active interest in centers' work.

Sources: Korea Science and Engineering Foundation (1991), "Science Research Centers/Engineering Research Centers: 1991," Seoul: KSEF, processed; Parker, L., "Industry-University Collaboration in Developed and Developing Countries," PHREE Working Paper, (Washington, D.C.: World Bank), processed.

Funded through the Korean Science and Engineering Foundation, the Bank supported program makes long term institutional development grants to universities on a competitive basis. Importance is given to supporting training at the postgraduate and at the undergraduate level "in areas where industrial personnel are needed." (Korea Science and Engineering Foundation 1991). In the 1989 and 1990 competitions, the Korean Science and Engineering Foundation made 30 grants to universities, 14 for Basic Science Research Centers and 16 for Engineering Science Research Centers to support activities in such fields as molecular plant biology, artificial intelligence, bio-process engineering, satellite technology research, and dialectic and advanced matter physics. The centers encourage exchange of personnel between universities, government research institutions and industries and their research projects are jointly developed by representatives of these sectors. They collect membership fees to support some of their operating costs from government institutions and private firms which makes them partners and ensures that the intended beneficiaries of the program take an active interest in centers' work.

In the three decades of World Bank educational lending to Korea, the government's participation in advanced scientific training and research has expanded while the private sector's contribution to national research and development investments has also grown. Korea now ranks with industrialized

countries in terms of the proportion of GNP invested in research and development, having invested as little as .57 % of GNP as recently as 1980. More than 2% of GNP was invested in research and development in 1987, 80% of which is carried out by the private sector (Carnoy 1992, 22). It is the parallel development of public sector scientific capacity and private investment that sets Korea apart from countries like Brazil with much larger science and technology systems. Indeed, Korea's ability to derive commercial benefits from its expanding infrastructure for scientific training and research prompted objections by representatives of some OECD countries to its most recent loans.

Lending for strengthening institutions for advanced scientific research and training is becoming increasingly important to the World Bank. The long term success of such investments, as the Korean experience indicates, is dependent on a wide range of supportive circumstances and coordinated government interventions. Macro-economic policies must foster technological innovation and private investment in research and development. This generates demand for the expertise and graduates of higher education and research institutions. Mechanisms must be established to facilitate utilization of these assets. Finally, there must be large national investments in raising educational attainment and especially in improving the quality of schooling to supply the productive sectors with the skilled labor that a technologically dynamic economy requires.

CONCLUSION

The World Bank has been most successful where through a series of project investments, it has developed a sub-sectoral strategy for intervention. In China, for example, project loans have involved different tiers of the sub-sector in ways that have generally strengthened the higher education system. Within the framework of China's Four Modernizations Plan of 1980, the World Bank began by supporting the country's elite national universities whose research and training programs were disrupted by the Cultural Revolution. World Bank funding facilitated construction and/or rehabilitation of university laboratories and libraries, updating instructional and research programs with foreign scientific expert assistance and upgrading the professional qualifications of academic staff through foreign training. Later projects addressed the needs of the provincial universities and other kinds of institutions of higher education while the most recent focus again on national institutions engaged in advanced scientific training and research. Over the course of more than a decade and through eight project investments in increasing quality, access and efficiency at more than two hundred national, provincial and municipal universities as well as various technical, vocational and scientific institutions, China's higher education system has been strengthened considerably (International Advisory Panel & Chinese Review Commission 1991). Although China is still far from matching the Newly Industrialized East Asian countries in the per capita output of scientists and engineers, the quantitative expansion of scientific and technological training has been impressive. World Bank assistance has facilitated China's re-entry into the international mainstream in many fields of scientific training and research (Frame and Narin 1987).

In Korea, the World Bank has also made multiple project investments through out the higher education sub-sector in the context of an integrated government strategy for quantitative expansion, quality improvement, strengthening national research and training capabilities in public sector and fostering their utilization by the private sector. In Indonesia which has received the most higher education investment since 1980, World Bank projects have been articulated with a strategy for development of the sub-sector only in recent years. In other countries, the World Bank has seldom taken advantage of its experience in the sub-sector.

The high costs and associated risks of supporting higher education has led to many projects focused on discrete teaching and research activities in high priority applied fields. There is little appreciation of the inter-relatedness of academic programs and of institutions of higher education. High quality instruction in engineering, medicine, agriculture and in applied social sciences, for example, requires sound training in the natural sciences, mathematics and even the humanities whose importance to national economic planning is less obvious and, thus, is less apt to attract donor support. Advanced scientific training and research requires strong undergraduate programs and a large, diversified higher education system so that undergraduate and postgraduate training do not compete for scarce staff and financial resources. Centers of excellence can not be maintained if they must bear the burden of accommodating most of the increasing social demand for higher education as well. The various institutional components of a higher education sub-sector, both public and private, constitute a system. How they relate to each other and to the higher education sub-sector needs to be taken into account. The World Bank can play a useful role in collaborating with governments and other donors in strengthening whole institutions and systems of higher education to support policy reforms.

Four lessons may be drawn from Bank lending experience. Most are intuitive but nonetheless important. First, national capacity for research and advanced scientific training cannot be developed and sustained without strengthening higher education and research at the system and institutional levels. Selective, targeted funding for training and research in high priority fields favored by many governments and donors will be ineffective unless institutional conditions and professional incentives are reinforcing. Little can be accomplished when low salaries require academics and researchers to have multiple jobs, careers are shaped by civil service regulations, opportunities for professional communication and recognition are limited and institutional budgets are inadequate to support maintenance and modernization of research and instructional facilities. Nor can "centers of excellence" be sustained for long when the systems and/or institutions in which they are embedded are in a state of collapse. Capacity building must comprehensively address the need to reform the financing and management of higher education and research systems.

Second, changing the role of the state in the financing and management of higher education and research is usually fundamental to these reforms. The dominant, directive role of the state in the financing and management of higher education and research in many developing countries must be reassessed in light of the economic transformations which have taken place in recent years. Public sector employment can no longer absorb the increasing number of graduates of higher education institutions. The importance of the public sector as a consumer of the products of research systems has diminished with the growth of small and medium sized private enterprises, the privatization of state owned enterprises, the dismantling of commodity marketing structures and opening of markets. These structural changes need to be reflected in public policies regarding the provision and financing higher education and research. While governments will continue to have a large role in higher education and research, efforts should be made to diversify higher education and research systems, to better articulate public and private investments and to focus government investment on what markets can not or will not finance and supply, and to steer the development of higher education and research "from a greater distance."

Third, efforts to increase the efficiency of government and donor investments in higher education and research must combine fostering accountability with increasing autonomy. Unfortunately, governments and donors have been more interested in improving the monitoring of research and training investments than in creating the right structures and incentives for institutions and staff. The latter often

involves changing traditions of subordination—liberating higher education and research institutions from civil service regulations, allowing them greater control over their budgets and factors that effect their costs, encouraging openness, transparency and competition in resource allocation, providing a greater measure self-governance and, of course, protecting the integrity of academic and scientific work.

Finally, countries with significant capacity for research and advanced scientific training will derive little benefit from their investments unless attention is also given to ways of fostering use of such capacity by enterprises, producers, government and by society as a whole. The dramatic growth of East Asian economies illustrates the close connection that must exist between educational and scientific and industrial policies. A country with a poorly educated work force, for example, cannot compete in a global economy even if it achieves some success in producing science and technology at an international level. Similarly, few benefits will result from investments in establishing outstanding scientific and higher education institutions if there is little domestic demand for their graduates and research outputs, and if macro-economic policies do not support market competition and technological innovation in production systems. In brief, careful thought must be given to what policies and structures must exist to take full advantage of government and donor investments in research and advanced scientific training.

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